

HYPED UP: STARTUPS RACE TO BRING THE HYPERLOOP TO LIFE

THE AUDACIOUS PLAN TO BUILD A TRAIN THAT TRAVELS 760 MPH

By James Vlahos [[/popsci-authors/james-vlahos](#)] Posted July 7, 2015

Maybe it was the Guns N' Roses pumping from the speakers. Or maybe it was the spell of Dubai itself, a newly minted megalopolis whose explosion from the Arabian sands screamed that the past was dead and the future had arrived. Whatever it was, when Dirk Ahlborn launched into his speech at the Middle East Rail conference in March, he basically gave the roomful of executives the finger. "There hasn't been any real innovation in the rail industry for—I don't know how long," he said. "Either disrupt yourself or you are going to be disrupted."

The audience sitting attentively in the convention hall included men in traditional dishdashas and women in black abayas. Other attendees wore suits and ties or even heels and short skirts. Together they formed the industry's elite, people who built trains and ran railways around the world, while Ahlborn was the CEO of a startup, Hyperloop Transportation Technologies (HTT), that hadn't carried a single passenger or laid an inch of track.

But restraint doesn't come naturally to Ahlborn, who wore, beneath his black suit, a white shirt open several buttons from the collar. Tall, with thinning brown hair and ruddy cheeks, Ahlborn began to pace the stage, TED-talk style, as he explained his vision for the future of transportation. "What is the hyperloop?" he asked. "It is a capsule, full of people, in a tube, elevated on pylons, going really fast. It's that simple."

Hyperloop capsules would use either a magnetic field or a continuous blast of compressed air to float above the bottom of the tube. Pumps would remove most of the tube's air, creating an extremely low-pressure environment. Minimal air means minimal friction, so the capsules would travel at up to 760 miles per hour, powered entirely by solar panels. "How would your life be if you could travel 600 kilometers in half an hour, with a ticket price of \$30?" Ahlborn asked. "If we achieve that, we really change the way we live."



Dirk Ahlborn  [HTTP://WWW.POPSCI.COM/SITES/POPSCI.COM/FILES/STYLES/LARGE_1X /PUBLIC/AHLBORN.JPG?ITOK=AIRSAQHZ]

Dmitri Alexander

The hyperloop concept isn't just a fantasy, says Hyperloop Transportation Technologies' founder Dirk Ahlborn, shown here near the Dubai Metro. "It's not like we want to invent an antigravity device."

Ah, the hyperloop—the same scheme that Elon Musk, the CEO of SpaceX and Tesla Motors, famously proposed in a white paper back in August 2013. The pronouncement incinerated the Internet, with some awe and lots of *are-you-kidding?* The technical challenges, while daunting, were potentially solvable, engineers opined. But economists estimated that Musk's projected cost of \$6 billion to connect San Francisco and Los Angeles was lowballed by a factor of 10 or more, not least because the cost for acquiring land for the route was grossly underestimated. The hype faded—but the outlandish idea was still alive.

II.

The hyperloop could be an entirely new form of transportation--one that is quicker, cheaper, and more fuel efficient than anything that has come before.

III.

By the end of the year, Ahlborn had launched HTT. In June 2014, Hyperloop Technologies (HT) entered the field, founded by Silicon Valley venture capitalist Shervin Pishevar and former SpaceX rocket engineer Brogan BamBrogan. And this past January, Musk himself was back, tweeting his intention to build a hyperloop test track, possibly in Texas. The two startups announced their own test-track plans shortly thereafter, with both hoping to break ground by 2016. The race for near-supersonic land travel was on.

Hyperloop proponents face uncountable hurdles—technological, political, and financial. But the massive challenges seem to inspire rather than intimidate them. The hyperloop, they believe, will be an entirely new form of transportation, one that is quicker, cheaper, and more fuel efficient than anything that has come before. “If you think about the things that have been most exciting in history, that have captured headlines, it’s humans taking flight, Lindbergh crossing the Atlantic, going into orbit and to the moon,” said XPRIZE Foundation chairman and CEO Peter Diamandis, who sits on HT’s board of directors. “We revel in moving people faster and farther than ever before, and hyperloop is in that same vein but in a different dimension.”

In Dubai, Ahlborn finished his presentation, and the audience applauded enthusiastically. He stepped down from the stage, and a man in a traditional white robe approached. I saw that he was Saqqaf AlAttas, a manager with Etihad Rail DB, which oversees operations for the United Arab Emirates national railway. He shook Ahlborn’s hand. “Everything starts with a dream,” AlAttas said. “And from what I saw, the hyperloop is not just a dream. It is already here.”

Ahlborn cut a Tony Stark-like figure as he strode through the convention hall after he spoke. The place looked like a giant IKEA showroom devoted to the sole purpose of selling trains. A maze of avocado-colored pathways funneled attendees between brightly lit displays featuring track ties and rail wheels. A German native who had also lived in Italy before settling in Southern California, Ahlborn chatted fluently with vendors in multiple languages. His manner was aloof, his comments sometimes barbed. “Is there anything new at this show?” he asked a person peddling software. “Has there been anything new in the past 10 years?”

In reality, Ahlborn is not a deep-pocketed tech magnate—at least not any longer. Sure, the 38-year-old had been an entrepreneur since he was 18. And he had made millions as, among other things, the CEO of a pellet stove company. Subsequently, though, he lost his fortune when real estate investments tanked in the financial crisis. While he may have looked like Stark in Dubai, back home he was renting his place on Airbnb.

Ahlborn runs HTT on a shoestring as well. The company had been launched on another one of his ventures, JumpStartFund, an online crowdsourcing platform that enables people to propose companies and then build communities of volunteers to bring those ventures to life. Ahlborn posted the hyperloop idea shortly after Musk announced it, and was overwhelmed by the response. More than 300 volunteers have signed contracts to officially join the startup, working at least 10 hours a week in exchange for stock options should the company make it as far as an IPO. They include engineers, business executives, and human resource and marketing professionals, and they form HTT’s entire staff. They also maintain day jobs at companies like Northrop Grumman, Airbus, and Cisco, and attend universities like UCLA, Stanford, and Harvard. With any profit years away, they are united less by materialism than by near-religious faith in the hyperloop’s potential. The team members envision themselves as builders of the first railroad, as pilots of the first plane. “We don’t necessarily require that you have the right credentials,” Ahlborn says, “but we require that you have the passion.”

Ahlborn scouted the trade-show floor for new converts. “We are a company of the people,” he explained to one prospect. “We’re crowd-powered.” The message resonated. A software engineer agreed to do a passenger-flow simulation for free.

A building-materials vendor suggested alternatives to concrete. Paul Priestman, who recently designed the cars for the London Underground's New Tube project, said his company could help with visual concepts. And Stephen Bradbury-Knight, a vice president of mobility and rail for the security-services provider TÜV Rheinland, offered to think about safety standards.

The next day, Ahlborn was joined by an HTT team member, a former Italian pop star-turned-tech entrepreneur, Gabriele "Bibop" Gresta. The three of us hopped onto the new Dubai metro and rode through a canyon of geometrically contorted skyscrapers. The ice-pick tip of the Burj Khalifa, the world's tallest building, spiked above the skyline. We disembarked at the Palm Jumeirah, a tree-shaped archipelago of artificial islands, and walked into the perfumed lobby of an expensive hotel. There we met a jocular Italian named Giuseppe Ugge, whose job, he told me, was to introduce the United Arab Emirates royal family to foreign business executives with ideas to sell.

Ahlborn was ready. Dubai would be the perfect location for a hyperloop, he said. Land is expensive in California—as it is near every major city in the United States and Europe—and navigating the gauntlet of regulatory and political hurdles will take years, if not decades. Dubai, in contrast, has abundant empty land, and a massive project can be built there with the say-so of a single person: Sheikh Mohammed, the emir of Dubai. Also, Ahlborn reminded Ugge, Dubai will host the World Expo in 2020. Since the first world's fair in 1851, the expo has introduced millions of people to such technological wonders as the telephone, typewriter, escalator, and talking films. Dubai, Ahlborn proposed, could be where the hyperloop makes its world debut.

Send me your plan, Ugge said, "and if it is good, we can introduce you."

At the end of an industrial block in Los Angeles, past the PlayPen strip club and a homeless man who snoozed facedown amid a collection of marijuana canisters, I entered the headquarters of BamBrogan and Pishevar's Hyperloop Technologies. I blinked at the incongruent scene inside—6,500 square feet of open warehouse illuminated by skylights and framed by exposed brick walls. Employees tapped at computers and scribbled on whiteboards.



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Hyperloop Track

Courtesy Hyperloop Transportation Technologies

Hyperloop Transportation Technologies plans to break ground in 2016 on a 5-mile track that will serve Quay Valley, a real-estate development in California. It will start carrying passengers as soon as 2018.

Whereas HTT has no office, no salaried employees, and essentially no cash resources, HT has a full-time staff of more than 30 people and \$10 million in seed funding, which it raised in just a few months. The company aims to hit \$80 million by the end of this year. (Pishevar, who is well on his way to becoming a billionaire thanks to investments in companies like Uber and Airbnb, pledged to put up half the money if needed.) The company has also recruited a well-connected board of directors. In addition to Diamandis, it includes political operative Jim Messina, who masterminded President Obama's 2012 campaign, and entrepreneur David Sacks, the founding COO of PayPal.

The calming vibe was carefully engineered. First-time passengers, after all, would be anxious about riding a bullet through the barrel of the world's longest gun.

It was April, not long after I'd returned from Dubai. BamBrogan strode up, a lanky 43-year-old whose thick mustache and twinkling eyes made him look like the ringmaster of some steampunk circus. When I asked about the skeleton key dangling from a lanyard around his neck, he cryptically pronounced, "This is the key to anything but not everything." Mischievous air aside, BamBrogan is a serious engineer: At SpaceX, he had led the early design of the Dragon spacecraft and the upper-stage engine of the Falcon 1 rocket.

The hyperloop, BamBrogan told me, was actually the latest iteration of an idea that has tempted engineers for more than a century: Put a train in a tube and remove most or all of the air. Rocketry pioneer Robert Goddard proposed the basic plan for what is known as a vacuum-tube transportation system in 1904. In 1969, the U.S. Secretary of Transportation wrote in *Popular Science* [<https://books.google.com/books?id=wSoDAAAAMBAJ&pg=PA51#v=onepage&q&f=false>] that the government was studying several "tube-vehicle system" concepts. Both HT and HTT are now pursuing the same notion.

The companies envision depressurizing the hyperloop tube to about 100 pascals—not a total vacuum, but 1/1000 of the natural atmospheric pressure at Earth's surface. With so little air to push out of the way, the capsule requires very little energy to attain near-supersonic speed. Solar panels atop the tubes, charging the equivalent of about five Tesla Model S batteries per capsule, should provide sufficient power to run the entire system.

Engineer Sandeep Sovani, working independently from HT and HTT, recently ran hyperloop airflow simulations for the software company Ansys. The overall concept is valid and has great promise, Sovani says. "I think tube transportation technologies are to this century what railways were to the 19th century."

Implementing the relatively simple idea, however, will be tough. To move the

capsules through the tubes, HT is investigating the use of linear induction motors, which would use the repulsive magnetic force between the hyperloop capsule and the tube floor to generate propulsion. Subway systems and roller coasters already use such motors, so BamBrogan initially thought he could buy the primary components off the shelf. But because those systems top out at around 70 miles per hour, not 700, existing technology probably won't work. "We would rather invent as few things as we need to," BamBrogan said, "but it looks like we may go in the direction of customizing a system."

At full speed, hyperloop capsules won't use wheels, so HTT may generate a magnetic field in order to levitate them. This is a proven technology: Witness maglev projects like Shanghai's Transrapid; its trains can hit 268 miles per hour. The problem is cost. Maglev trains are more expensive to build than conventional ones—according to one source, Transrapid cost \$63.2 million per mile of track—and if HTT has a radical idea to slash that expense, Ahlborn hasn't revealed it yet.

Both companies are also investigating a different strategy: air bearings. Jets of air blasting down from beneath the capsules would enable them to skim through the tube like a puck streaking across an air-hockey table. Computer designers currently use air bearings to float the spinning platters inside hard drives, and manufacturers use them to levitate heavy objects in factories so they are easier to manipulate. Air bearings make theoretical sense in vehicles too—they're low friction and don't wear out the way wheels would. The U.S. Air Force successfully tested air bearings on rocket sleds back in the 1960s. HT could learn from those experiments, BamBrogan said, but the sleds traveled on a monorail track and so were a fundamentally different type of vehicle. The hyperloop's bearings, like its motors, will need to be invented almost from scratch.

Since a hyperloop tube would not be totally depressurized, the air that remains poses yet another engineering challenge. If the capsule fits snugly inside the tube, it would have to push an increasingly high-pressure mass of air ahead of it, a phenomenon known as pistonning. (Imagine a plunger pushing liquid through a syringe.) One solution, Musk suggested, would be to make the tube's diameter roughly twice the width of the capsule so some of the air could pass around it. He also proposed mounting a giant compressor on the front of the vehicle. The compressor would suck in air and pack it down to perhaps 1/20 of the volume, then blast it out through the air bearings and pump it into the tunnel behind

the capsule.

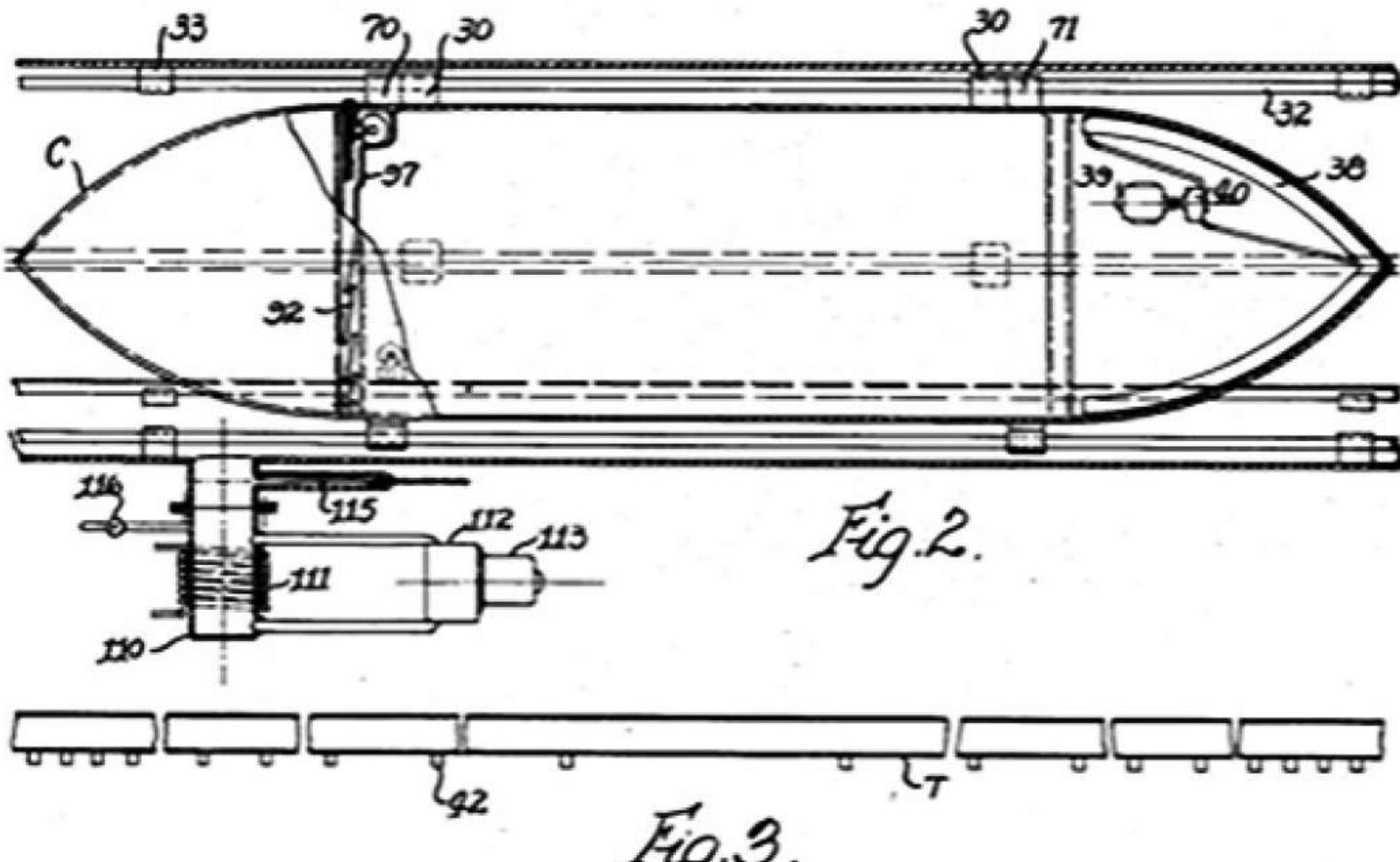


Fig. 2.

Fig. 3.

INVENTOR
Robert H. Goddard.
BY
Chas. T. Hawley
Atty.

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Vacuum Train

Robert Goddard proposed the vacuum train as a freshman at Worcester Polytechnic Institute in 1904. As he wrote later, "The possibilities of this method of travel are startling...a running time from Boston to New York of ten minutes is perfectly possible."

HT is using Musk's 2-to-1 tube-to-capsule ratio as the starting point for its design. The company is also studying how to incorporate an air compressor. Josh Giegel, an HT engineer, showed me a tiny piece of twisted metal that he had recently 3-D printed in the possible shape of a hyperloop compressor blade. He would soon be testing it in a wind tunnel behind the office.

How To Solve The Pistoning Problem

1. Let It Blow By

2. Pump It Through

Bottom Line:

But when aerospace engineers at NASA's Glenn Research Center did an independent analysis of the hyperloop concept, they concluded that to prevent pistoning, the tube would likely need to be four times the width of the capsule, even with a compressor. The finding didn't invalidate the hyperloop concept, Justin Gray, a member of the NASA team, explained when I phoned him at Glenn. But if a tube hundreds of miles long needed to be twice as wide as projected, the cost of construction would balloon.

Throughout my visit, BamBrogan ping-ponged between an entrepreneur's brashness and an engineer's caution. "I don't think anybody thinks that hyperloop is a bad idea," he said. "But a few people do think hyperloop won't exist or can't exist." That's why the company is gunning to build a test loop as soon as possible. A successful demonstration, BamBrogan said, would be "our Kitty Hawk moment, when the thing flies."

Silicon Beach, located across town from HT's headquarters, hosts Google, Yahoo, Snapchat, and hundreds of other tech startups. Long before those companies, though, the area was home to a different kind of entrepreneur: the aviator Howard Hughes. The cavernous wood-paneled hangar where he once built planes now holds a full-scale hyperloop simulator. Eight feet wide and ringed by glowing white lights, it looks like a giant Cheerio crossed with a portal to the afterlife. I stepped into the capsule and sat down next to Marta Nowak, an architect involved in the design. "OK," she said, "are you ready to take a ride?"

The lights in the hangar dimmed. Atmospheric music began to play, with piano arpeggios dancing gracefully on top. "We are still in the station; the doors just

closed," Nowak said. Then, she informed me, the capsule began accelerating. Hyperloop critics have complained that the ride would be nausea-inducing—"New Super-Fast Transport System Powered by Passengers' Screams," *The Onion* quipped. But according to Nowak, passengers would actually feel and hear very little due to the gradual acceleration—it would take several minutes to reach full speed—and broad turns. The experience would be like flying in a plane at 30,000 feet, only quieter. The lighting in the simulator was low and purplish. "We can look back and see our fellow passengers," Nowak said, and I glanced over my shoulder at a dozen rows of seats extending behind me.

Hyperloop tubes are solid, eliminating any view, so instead of windows, the builders installed flat-panel displays on the capsule walls. They started out showing starry skies, and then the cabin brightened and the scenery changed to farmland, a lake, and a forest streaking by. When we reached our destination, I felt like I had time-traveled in a high-end spa. Nowak said the calming vibe was carefully engineered. First-time passengers, after all, would be anxious about riding a bullet through the barrel of the world's longest gun. "If people try the hyperloop once and like it, they are going to take it again," Nowak said. "But if they don't..."

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Looking To Get From San Francisco To Los Angeles? Here's How Long It'll Take

Sources: Department of Transportation; Oak Ridge Transportation Energy Data Book; Google Maps; Mikhail Chester, Arizona State University; Elon Musk, Hyperloop White Paper; Megan Ryerson, University of Pennsylvania; California High Speed Rail Authority

Hyperloop might be fast, but riders will still need to reach a station, board a capsule, and travel to their final destinations. Those extra elements will slow down the 30-minute dream. But will hyperloop beat other options anyway? To find out, we engineered an imaginary race. Six people leave an apartment in San Francisco's Mission District and meet in Highland Park, Los Angeles, to settle a dispute over the best tacos on the West Coast. Each will take a different mode of transit: a train, a plane, a car, the hyperloop, the (also hypothetical) California High-Speed Rail—and a fixed-gear bicycle, the single-speed mainstay of hipster transport.—*Katie Peek*

The mock-up of the capsule—a Styrofoam-and-plywood vessel augmented by a video projector—had been built by post-graduate students in the department of Architecture and Urban Design at UCLA. Under the direction of architects Craig Hodgetts and David Ross, the students had also created computer models of the station and capsules. The UCLA team collaborated with HTT as part of a program called Suprastudio, which pairs students with industry partners to give them real-world expertise.

I exited the simulator feeling sublime. But to skeptics, such as transportation blogger Alon Levy, my experience might be emblematic: The hyperloop was a mirage—unfeasible and expensive. What's more, they said, Musk may have had ulterior motives in proposing the concept in the first place. He makes no secret of his disdain for California's plan to build a \$68 billion conventional high-speed rail line. Levy and others suspect that Musk's objective may have been to erode support by touting the much-sexier hyperloop—look, folks, only \$6 billion for a supersonic levitating train!

Whatever Musk's motivation, the idea is now bigger than him. That's why a UCLA student told me that she and her friends spent 14 hours a day toiling on prototypes, why BamBrogan and Pishevar are investing so much money, and why HTT's volunteers comprise something that is more than a company and closer to a movement. They are all infected with the Walt Disney strain of futurism in which you try to engineer a bigger, brighter tomorrow, not merely another smartphone app. In the capsule I asked Nowak if she would be excited to ride for real. "Absolutely," she said. "We could walk right now to the station, and in 30 minutes have dinner in San Francisco. That's crazy!"

After the ride I wandered through a door in the rear of the workspace and into an adjacent hangar. It was even more vast—315,000 square feet of silence and shadows. A cathedral of audacious engineering, this was where Hughes had built the Spruce Goose, whose 320-foot wingspan has never been surpassed.

The plane was flown only once, for a mile, before it was mothballed. An expensive, widely mocked boondoggle, it serves as a cautionary tale for the hyperloop's creators. But the Spruce Goose, wider than a football field and built almost

entirely from wood, is also an inspiration. You might not succeed at building something crazy, something so monumental and complex that most people say it can't be done. But it is hard to resist the impulse to try.

Air remaining inside the hyperloop tube will pile up in front of the capsule and slow it down. NASA engineers analyzed a potential two-part solution.



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Musk proposed making the tube nearly twice as big as the capsule. This would allow enough room for some, but not all, of the air to flow around the capsule as it speeds through at Mach 0.99.

A compressor can suck air in and pump it out below and behind the capsule. But the air must first be slowed by a diffuser to Mach 0.6. Higher speed requires a bigger diffuser—and a larger capsule.

The tube might need to be four times the width of the hyperloop capsule, and the speed should be capped at 620 mph, or roughly Mach 0.80. That would raise the construction costs and add five minutes to an LA to San Francisco trip.

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ELON MUSK [/TAGS/ELON-MUSK], MAGLEV [/TAGS/MAGLEV], JULY 2015 [/TAGS/JULY-2015],
FEATURES [/TAGS/FEATURES], TECHNOLOGY [/TAGS/TECHNOLOGY], HIGH-SPEED RAIL [/TAGS/HIGH-SPEED-RAIL-0]